SAWYER

Construction of the Danville, Urbana & Champaign Interurban Railway

Civil Engineering
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CONSTRUCTION

OF THE

DANVILLE, URBANA, AND CHAMPAIGN INTERURBAN RAILWAY

BY

FRED SCOTT SAWYER

THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN

CIVIL ENGINEERING

COLLEGE OF ENGINEERING

UNIVERSITY OF ILLINOIS

PRESENTED JUNE, 1905

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

FRED SCOTT SAWYER

ENTITLED CONSTRUCTION OF THE DANVILLE, URBANA AND CHAMPAIGN

INTERURBAN RAILROAD

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Civil Engineering

Ira O. Baker

HEAD OF DEPARTMENT OF Civil Engineering

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Construction of the Danville, Urbana and Champaign Interurban.

The Danville, Urbana and Champaign Interurban is an electric line connecting Danville, Illinois, with the twin cities of Champaign and Urbana, and comprises a portion of the Illinois Traction System which is under the control of the McKinley syndicate.

When the road was first projected it was thought by many that any such road between Danville and Champaign would not pay as there was not a large enough volume of business carried on between the two cities and the intermediate towns along the proposed route. Between Danville and Urbana there are nine small towns whose population varies from fifty to seven hundred, St. Joseph, the largest, being about eleven miles east of Urbana.

Champaign and Urbana combined have a population of about seventeen thousand and Danville about twenty-four thousand. It seemed reasonable to believe that a road could not operate on a paying basis having only towns of the above mentioned size to draw from; but the road has proved even more of a paying investment than its promoters had hoped.

In order to keep the expenses low the character of the construction, while solid, was of such a nature as to decrease the cost as much as possible, which was accomplished by making the profile correspond closely to that of the country.

Work was commenced on the road in August, 1902, and was carried on rapidly, cars making the run from Danville to Champaign by the first of September, 1903. The length of the line is thirty-three and six tenth miles, of which about two miles were al-

ready constructed and in operation by the city lines. The road is a single track line having frequent turn-outs for meeting points. The old city line in Danville is double-tracked, as also most of the line in Champaign and Urbana.

The engineering party consisted of the city engineer of Champaign, who acted as chief of party and instrumentman; two chainmen, an axeman, and a rodman. The only complete survey made was a locating line, that being all that was necessary as there were few difficulties encountered in following the right-of-way of the Cleveland, Cincinnatti, Chicago and St. Louis Railroad. Several lines were run and a different location plotted at the Middle Fork valley, which is located about three and a half miles west of Danville, before a desirable line was established. The only way in which to build the

road at this point so that the high water would certainly not cause trouble was to construct a high steel trestle at the level of the top of the side hills; but this plan was out of the question on account of its expense. A few hundred feet south of the present line the valley is narrowed down by two high knolls, which project out, both being at the same level practically as the surrounding country. It would seem as though just as good a line, if not a better and safer one, could have been run so as to have taken advantage of these projections, and then have used a high steel bridge or a concrete arch with perhaps some earth fill. The amount of cut and fill would have been greatly reduced over the large amount used in the present line; but the cost of a high bridge was estimated to be too great for a new road of

uncertain money-making powers.
This plan would have cut out
four sharp curves around a mine
shaft which is situated directly
on the line of the present road.

Since the completion of
the road the work of the locating
engineer has been subject to
much adverse and seemingly well-
deserved criticism, and it seems
safe to say that the location was
not first class. Doubtless the engin-
eer had reasonable excuses at the
time for his work of location, though
the only one apparent at present is
that time was an important
factor as the road had to be put in
operation so as to hasten an income.
For example, about one mile and a
half west of the Middle Fork the
road crosses two coal tracks lead-
ing to some coal mines in the
Mission Field coal district, one track
belongs to the Chicago and Eastern

Illinois Railroad and the other to the Big Four. The location of these tracks together with the interurban, proposed and as it is, are shown in Figure 1.

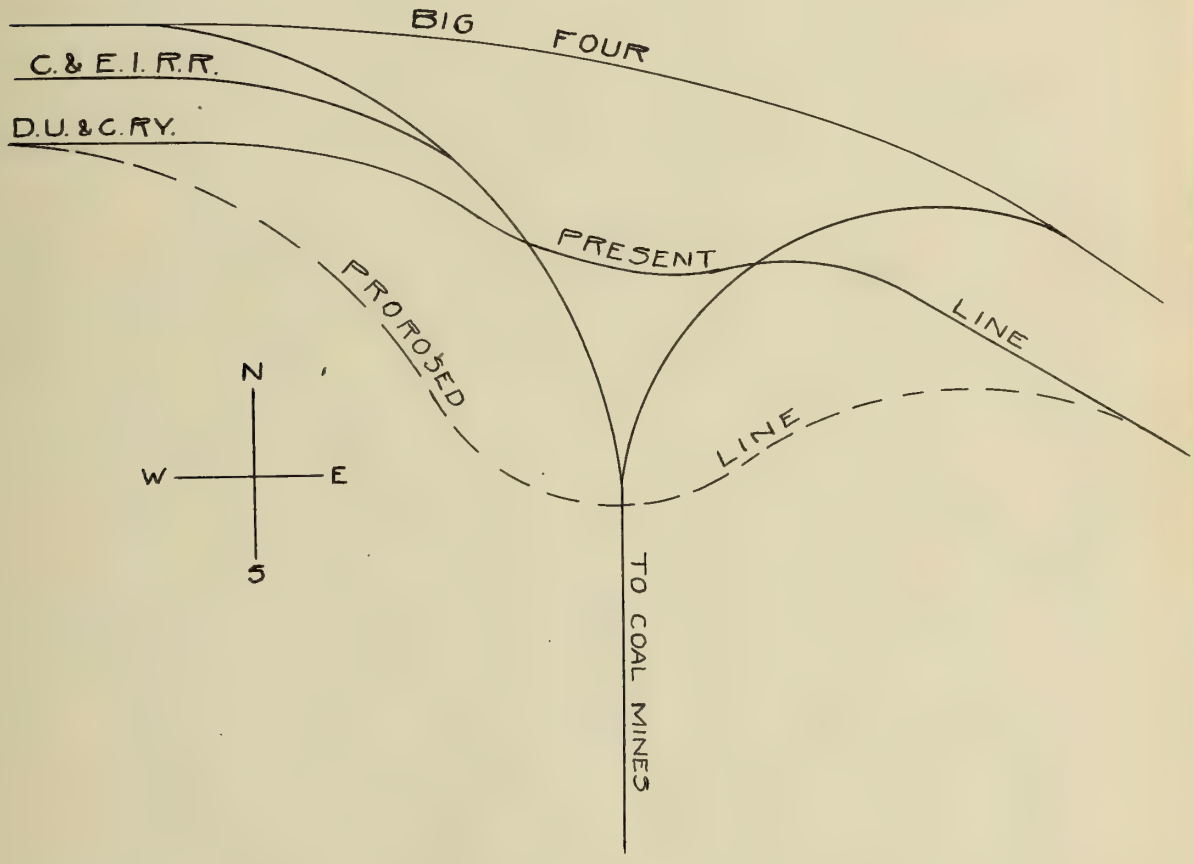


FIGURE 1.

As originally located the line was to the position of the dotted line in the sketch. This line is not as satisfactory as the present location, since

the curvature in the original line is both sharper and greater, and besides it would have been in a deep cut, which would obscure the view of the motorman. The locating engineer thought that the elimination of one crossing and the consequent decrease of cost of special work would more than compensate for the easier curves of the present line; but in this he overlooked the increased danger due to the curved line and the deep cut.

Again, in several places the engineer seems to have been satisfied with the first line run, when a little study and investigation would have shown that a better line could have been had cheaper. For example, he could in a number of places have had long stretches of tangent, where he introduced curves for no apparent reason. In a few places jogs in the line were necessary because

of a difference in width of right-of-way of the Big Four Railroad, which this line closely parallels. From Danville to the eastern limits of Urbana there are sixty-one curves, varying from thirty minutes to one hundred and eight degrees, the total length of curved track being two and three tenths miles. Since the road was finished, it has been the work of the engineer of maintenance of way to eliminate the sharper and to take out unsightly kinks as far as the earnings of the road would justify; but as this work was carried on under traffic, it has been exceedingly expensive, also on account of the inability to secure right-of-way on terms as favorable as those obtained in the original construction. The expense of these changes illustrates the folly of a hasty location. It is the purpose of the management to make changes in the alignment and the profile as fast as the

earnings justify, with the expectation of securing a very satisfactory line, which shall correspond closely to that of the Big Four.

The right-of-way was acquired by purchase or gift. Many farmers and property owners along the line were far-seeing enough to know that they would not be the losers if they gave the interurban company a strip of land. As before stated, the line parallels the Big Four Railroad, for practically the entire distance the two rights of way being adjacent; and therefore the farmers were more likely to give a piece of land than if the electric line cut through the middle of their property. On the other hand, many wanted the highest price obtainable and got it, the maximum price paid being about one hundred and fifty dollars an acre. Since the road was finished and in operation, several changes in loca-

tion have necessitated the purchase of additional land, and in some instances the price went far above one hundred and fifty dollars an acre, though in some cases only a small fraction of an acre was bought.

The width of right-of-way varies from two to four rods, though in one place, for a distance of two hundred feet, the width is only twelve feet owing to a property owner refusing to sell more than the company absolutely needed. The right-of-way at the Middle Fork cut is about one hundred feet in width in order to keep the sides of the cut, when softened by rain, from sliding down on the track; but even with a width of one hundred feet, on account of the great depth of the cut and the nature of the soil, it is found that the side slope is still too great, as it takes only a very light fall of rain to bring down large quantities of gravel

and shale. Most of the variation in the width of the right-of-way along the line is due to the fact that the Big Four's right-of-way varies from fifty to one hundred feet.

After the survey was completed construction was commenced. Work began at the Champaign end several months ahead of the beginning at the Danville end, as it was the intention to have the two construction gangs meet at the the Middle Fork Valley. The tracks of the Urbana and Champaign Electric Railway were already in operation as far as the court house in Urbana, thus cutting off almost two of the thirty-four miles to be constructed; and at the Danville end the city lines were in operation for a distance of a quarter of a mile west of the public square, the proposed terminus of the interurban line, thus the total

length actually to be constructed was practically thirty-two miles.

The work of construction from Danville west began in February, 1903. The method of construction was identical on both divisions, the entire work being under the control of one superintendent and his assistants.

The first work to be undertaken was that of clearing the right-of-way and making the subgrade. This was carried on both by contract and by laborers of the company, about two-thirds of the work being carried on by contract. The work of clearing the right-of-way was quite an item owing to the fact that for about eleven miles the right-of-way was in the former public highway, therefore the hedges and trees bordering the wagon road had to be pulled or blasted out and a new highway laid out and graded, just

south of the right-of-way. In all towns except Ogden the line was located on the highway or adjacent to it, but at Ogden the line ran across private property and several buildings including an elevator, also a lumber yard had to be moved to make room for the track. The entire amount of grading and clearing was let to one contractor. He was paid each month the amount of the monthly estimate handed in by him and checked by the superintendent.

Work on the track followed the completion of the sub-grade. The steel and ties were shipped to towns along the interurban over the Big Four, and from those places were hauled along the right-of-way. One gang placed the ties and laid the rails, and a second gang followed immediately after spiking the rails. The ties used were, with the exception of three or four thous-

and, No. 1 white oak, purchased in northern Wisconsin and Michigan. the contract price being fifty-eight cents per tie, the freight charges being deducted from the bill. The three or four thousand ties mentioned above were an inferior grade of white oak. known as No. 2 or seconds. These were bought in Illinois and Indiana at thirty-five cents, freight charges being deducted from the bill. Before any shipments were made an inspector was sent to the yards where the ties were stored and checked them over; the ties were again inspected and counted on being taken from the cars along the right-of-way.

Thirty foot, sixty and seventy pound rails were used, the track from St. Joseph to Urbana being of sixty-pound rails and from St. Joseph east, seventy-pound. The rails were the American Society of Civil Engineers standard, and the total order was divided

about evenly between the Cambria Steel Company and the Carnegie Steel Company, the average price being $31.20 per ton. The rail joints used at first consisted of simple twenty-four and thirty-inch angle bars, having two bolts to the rail on tangents and three bolts on curves. The price of the splice bars per hundred pounds was $2.10. During the latter part of construction the use of this style of rail joints was abandoned, and the Webb rail joint substituted on account of its superiority. This joint consists of two seasoned blocks of wood twenty-two inches long, one placed on each side of the rail at the joint, and metal plates on the outside of each block, the whole being held in place by two bolts to each rail. The advantage of this joint is that the seasoned wood, of which the blocks are made, swells on account of the moisture, thus making an extremely

tight fit and holding the two rails firmly in place. Twenty-two inch Weber joints to fit an American Society of Civil Engineers standard rail, complete with bolts and nuts cost $1.34 per joint. The rail spikes used were the ordinary five and a half inch by nine-sixteenths railroad spikes, and were bought by the car load at $2.05 per hundred pounds.

The cost of rails per mile was $4,900, this amount including the cost of rail joints and bonding wire. The cost of ties, spaced twenty-six hundred to the mile was $1.700 per mile.

The poles carrying the overhead work were placed in span, that is, a pole on each side of the track at the extreme edge of the right-of-way, spaced ninety feet apart. The poles were of cedar, purchased in northern Wisconsin and Michigan, thirty and thirty-five

feet long, the upper end having a diameter of seven inches. The contract price for poles was $3.50 for thirty foot lengths and $4.75 for thirty five foot lengths, freight charges being deducted from the bill. The poles were placed seven feet in the ground, the portion of the pole to be below the surface being treated with a heavy coat of tar to prevent rotting.

The overhead work consisted of the span wire, trolley wire, three high tension wires, a feed wire and four telephone wires. Two of the high tension wires were placed on a cross arm and the third carried by an insulator at the apex of the pole. The feed wire is placed three feet from the top, and is carried by a side bracket and insulator. The telephone wires are carried on the opposite line of poles on a single cross arm. The trolley wire is the figure-eight pattern, made of hard-drawn

copper wire, No. 4 Brown and Sharpe gauge, and cost $14.15 per hundred pounds. The feed wire was No. 12 Brown and Sharp gauge, low Okonite and cost $21.00 per hundred pounds. The telephone wire was No. 12 galvanized iron wire and cost five and three-eighth cents per hundred pounds. Seven and a half inch glass insulators, tiffe M. G., were used, costing sixteen cents a piece. The cost of overhead material was $1400 per mile

The right-of-way was fenced only on part of the line during construction, the work not being finished till the spring of 1905, on account of disputes with farmers as to the boundary line. The material for fencing consisted of wire, posts, fence stretchers and tools, all of which was furnished by the company; while the work of erecting was done by contract, the price paid

being seven cents per rod. The posts used were of cedar, halved, eight feet long, seven inches in diameter and cost sixteen and a half cents a piece. The lower two and a half feet of the posts were coated with tar, imbedded two feet in the ground, and were spaced one rod apart. The fencing used was the American fence, with a twelve inch mesh, four feet high, costing eighteen cents per rod.

Culverts were of four different styles, pile, wooden box, vitrified pipe, and galvanized iron. There were six pile culverts varying in length from nine to twenty feet, and made of eight by twelve inch stringers upon which the ties rested. Wood box drains were used where the drainage area was very small, the cross section of the box as a rule being about one square foot. Vitrified pipe were used most

extensively as culverts and varied in size from eight to twenty-four inches. A very few galvanized iron pipe were used, the barrel of the culvert being made of sheets of iron rolled into twenty-four inch cylinders and fastened by rivets. It is the intention of the company, as soon as the earnings permit, to replace the large culverts and the wooden trestle at the Middle Fork with concrete arches. The bridges and pile culverts were all built by contract, the price being $5.50 per linear foot.

No attempt at ballasting was made until the spring of 1903, owing to the fact that practically all of the ballast came either from gravel pits at the Middle Fork or from Danville and consisted of either cinders or gravel. A small quantity of cinders and a very poor grade of gravel came from the Champaign

power plant and Urbana gravel pits respectively. As gravel trains were run mainly at night and as there was a scarcity of ballast cars, the work of ballasting proceeded very slowly, in fact the work is not yet finished and at the time of the writing of this thesis (May, 1905) gravel and cinders are being hauled every night. One of the drawbacks to the road is the fact that the ballast is very unsatisfactory, being a poor grade of gravel, composed mostly clay, sand and a comparatively small percentage of stone. When placed on the road bed the first good rain washes out the fine sand and except for a few pebbles there is no evidence that the track had been ballasted. What gravel was purchased before the line reached the Middle Fork came from the gravel pits at Urbana and cost seventy cents per cubic yard.

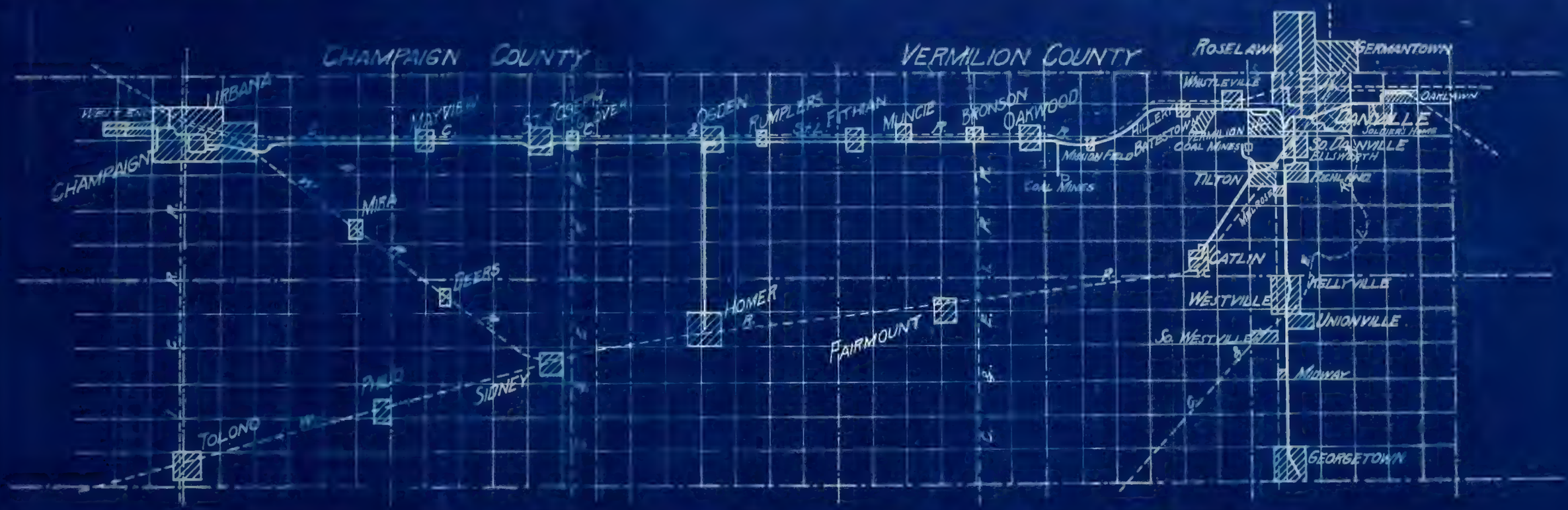
A large item of expense was the cost of special work, including crossings, switches, frogs, and Y's. The original number of switches put in was eighteen, some having only a stub track and others two ends. In the last two years there have been changes and additions in the switches owing to changes of schedule, thus necessitating new meeting points, also on account of the increased express and freight traffic demanding more sidings. An single end switch cost $72.50. The cost of crossings varied, depending on the angle and alignment - that is, whether the crossing was on a curve or stretch of tangent. The average cost of a crossing was $325. One "Y" was used, costing $700.

The approximate cost for one mile of the road is given in Table I. This table has to do only with the cost of the line and therefore does

not include the cost of rolling stock. The cars used at the beginning were small forty foot cars, capable of a speed of about forty miles per hour and costing $3700. The cost of power is low, as only slight additions had to be made to the power plants in addition to a battery house at St. Joseph and a transformer station at Fithian. At St. Joseph an old house was repaired to contain the batteries, but at Fithian a large brick building was erected having two rooms, one for the transformers and the other large enough to hold two interurban cars. The cost of car barns is not included in the following table as that item is not classified under the head of track. Besides the barn just mentioned at Fithian, the city barns at Danville and Champaign had small additions; but the total cost of car barns was very low, being about two hundred

dollars per mile of track.

total cost of the road, inclusion of the items mentioned above.



DANVILLE, URBANA & CHAMPAIGN RY. AND TERMINAL CONNECTIONS

dollars per mile of track.

TABLE I.

COST PER MILE OF DANVILLE, URBANA AND CHAMPAIGN INTERURBAN RAILWAY.

Power	$1,500
Rails	4,900
Ties	1,700
Spikes	170
Engineering, superintedence, instruments, carfare, rents, law fees, etc.	500
Right of Way and fence	300
Overhead material, pole, wire, etc.	1,400
Culverts and bridges	350
Grading (by contract)	1,500
" , by employes	600
Labor on overhead work, bonding gang	800
Steel and tie gang, spiking gang	1,000
Clearing right-of-way, surfacing, etc.	500
Total cost per mile	$15,220

This gives about $517500 as the total cost of the line, exclusive of the items mentioned above.

The power for the line is direct current fed into the trolley line from both the Danville and Champaign power plants. The machine at Danville is a direct-current 150 K.W. generator, belt driven, and the one at Champaign is a 500 K.W. double-current generator, direct connected to a Russell engine. The alternating current side of this generator feeds current into the three phase-high tension transmission line which extends the whole length of the road. The current is stepped up from about three hundred and fifty to fifteen thousand volts. Under ordinary conditions, however, the high tension lines are used only from Champaign to Fithian. At Fithian there is a rotary-converter substation containing a 150 K.W. converter and three transformers. At this place the direct current is fed into the trolley wire at six hundred and

fifty volts, the voltage at the Danville and Champaign plants being only six hundred volts.

The feed wires extend only from Danville to the Middle Fork as they are not needed any further since the rotary-converter at Fithian raises the voltage sufficiently over the rest of the road.

At St. Joseph there is a storage battery sub-station which simply floats on the line and takes care of the peaks of the loads due to the starting of cars, particularly when these peaks are near together. When necessary, as in case of breakdowns, either power station can furnish current for the high-tension line and feed the sub-station at Fithian; this gives great security against a shut-down due to a shot circuit or a break down at either plant.

Thus far the income of the road has been about $120,000 per year

but the earnings are increasing as the freight and express business is developed. The income is about $3,500 per mile per year

The total population affected by the interurban, that is, as patrons of the road, is about 51,000, distributed as follows

Champaign and Urbana	17,000
St. Joseph	700
Ogden	250
Fithian	300
Muncie	200
Oakwood	400
Bronson	50
Batestown	200
Hillery	50
Vermillion Heights	3,000
Danville	24,000
Farmers within a strip three mile wide on each side of the road, 25 persons per square mile.	4,950
Total	50,900

Dividing the total increase per year by the above population gives $2.35 the amount contributed by each person per year toward the support of the road

The rolling stock consists of six passenger cars, including two forty foot cars, two forty eight foot, and two fifty six cars; twenty-three coal cars, of which nineteen are standard railroad size; two express cars, an electric locomotive for hauling gravel and coal, and several work and construction cars. Only four cars make regular runs, leaving each terminal every hour, the others being held in reserve in case of accident or a break down. The coal and express cars are kept busy all the time, and it is in this kind of traffic that the road expects to make a large part of its profits.

The road has two branch lines: one, a coal track about half a

mile long running south from a point on the main line seven miles west of Danville; the other, a passenger and freight line to Homer, a town five miles south of Ogden. This line, though only in operation since May, 1904, has been doing a large freight and express business consisting mostly of coal and groceries. On account of the low express charges almost all of the Homer grocers ship their supplies from Danville over the interurban.

At Danville the Illinois Traction System has two other interurban lines, one running due south twelve miles to Georgetown, and the other, southwest six miles to Catlin. Considering their length and territory reached they are even more of a paying proposition than the Danville, Champaign line.

It is very notable that the construction of the Danville, Urbana

and Champaign line will add impetus to the projection to the projection of other roads in this part of the state, since the public has had an example of a line connecting two average terminals at a comparatively low cost of construction, and since construction is attended with such few difficulties. There is no reason why cities such as Danville and Champaign should not be important interurban centers for the east central part of Illinois. In every direction within distances varying from twenty to forty miles there are many prosperous towns, having populations varying in size from three to ten thousand.

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